Section 1

Changing Earth's Surface

Reading Preview

Key Concepts

- What processes wear down and build up Earth's surface?
- What causes the different types of mass movement?

Key Terms

- erosion
- sediment
- deposition
- gravity
- mass movement

Target Reading Skill

Comparing and Contrasting As you read, compare and contrast the different types of mass movement by completing a table like the one below.

Mass Movement

Type of Mass Movement	Speed	Slope
Landslide		

Lab zone **Discover Activity**

How Does Gravity Affect Materials on a Slope?

1. Place a small board flat on your desk. Place a marble on the board and slowly tip one end of the board up slightly. Observe what happens.
2. Place a block of wood on the board. Slowly lift one end of the board and observe the result.
3. Next, cover the board and the wood block with sandpaper and repeat Step 2.

Think It Over

Developing Hypotheses How do the results of each step compare? Develop a hypothesis to explain the differences in your observations.

The ground you stand on is solid. But under certain conditions, solid earth can quickly change to thick, soupy mud. For example, high rains soaked into the soil and triggered the devastating mudflow in Figure 1. A river of mud raced down the mountainside, burying homes and cars. Several lives were lost. In moments, the mudflow moved a huge volume of soil mixed with water and rock downhill.

Wearing Down and Building Up

A mudflow is a spectacular example of erosion. **Erosion** is the process by which natural forces move weathered rock and soil from one place to another. You may have seen water carrying soil and gravel down a driveway after it rains. That's an example of erosion. A mudflow is a very rapid type of erosion. Other types of erosion move soil and rock more slowly. Gravity, running water, glaciers, waves, and wind are all causes, or agents, of erosion. In geology, an agent is a force or material that causes a change in Earth's surface.

FIGURE 1
Mudflow
A mudflow caused by heavy rains in San Bernardino, California, brought this ambulance to a stop.

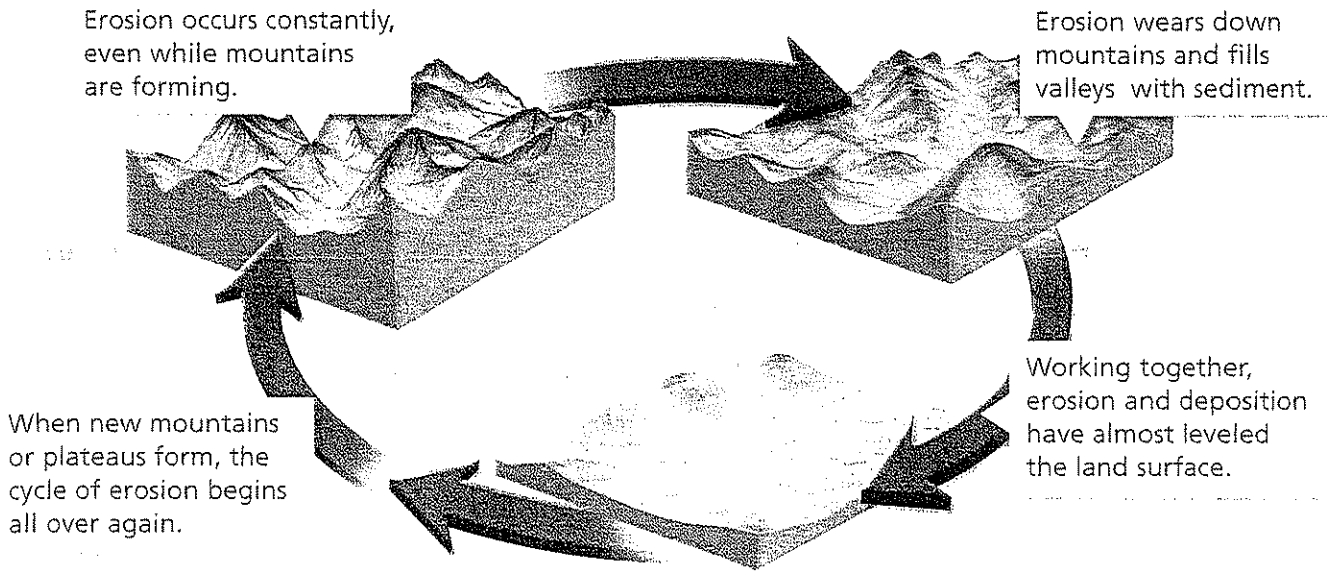


FIGURE 2
Cycle of Erosion and Deposition
Over millions of years, erosion gradually wears away mountains while deposition fills in valleys with sediment.
Predicting *What would happen to the surface of the land if uplift did not occur?*

The material moved by erosion is **sediment.** Sediment may consist of pieces of rock or soil or the remains of plants and animals. Both weathering and erosion produce sediment. **Deposition** occurs where the agents of erosion, deposit, or lay down, sediment. Deposition changes the shape of the land. You may have watched a playing child who picked up several toys, carried them across a room, and then put them down. This child was acting something like an agent of erosion and deposition.

Weathering, erosion, and deposition act together in a cycle that wears down and builds up Earth's surface. Erosion and deposition are at work everywhere on Earth. As a mountain wears down in one place, new landforms build up in other places. The cycle of erosion and deposition is never-ending.

Reading Checkpoint **What is sediment?**

Lab zone Skills Activity

Runoff and Erosion

Moving water is the major agent of the erosion that has shaped Earth's land surface. Erosion by water begins with the splash of rain. Some rainfall sinks into the ground. Some evaporates or is taken up by plants. The force of a falling raindrop can loosen and pick up soil particles. As water moves over the land, it carries these particles with it. This moving water is called runoff. **Runoff** is water that moves over Earth's surface. When runoff flows in a thin layer over the land, it may cause a type of erosion called sheet erosion.

Amount of Runoff The amount of runoff in an area depends on five main factors. The first factor is the amount of rain an area receives. A second factor is vegetation. Grasses, shrubs, and trees reduce runoff by absorbing water and holding soil in place. A third factor is the type of soil. Some types of soils absorb more water than others. A fourth factor is the shape of the land. Land that is steeply sloped has more runoff than flatter land. Finally, a fifth factor is how people use the land. For instance, a paved parking lot absorbs no water, so all the rain that falls on it becomes runoff. Runoff also increases when a farmer cuts down crops, since this removes vegetation from the land.

Generally, more runoff means more erosion. In contrast, factors that reduce runoff will reduce erosion. Even though deserts have little rainfall, they often have high runoff and erosion because they have few plants. In wet areas, runoff and erosion may be low because there are more plants to protect the soil.

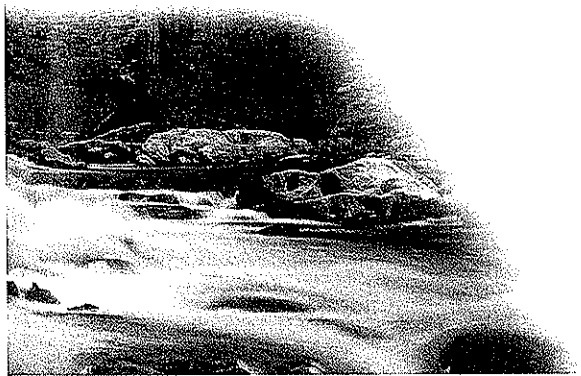
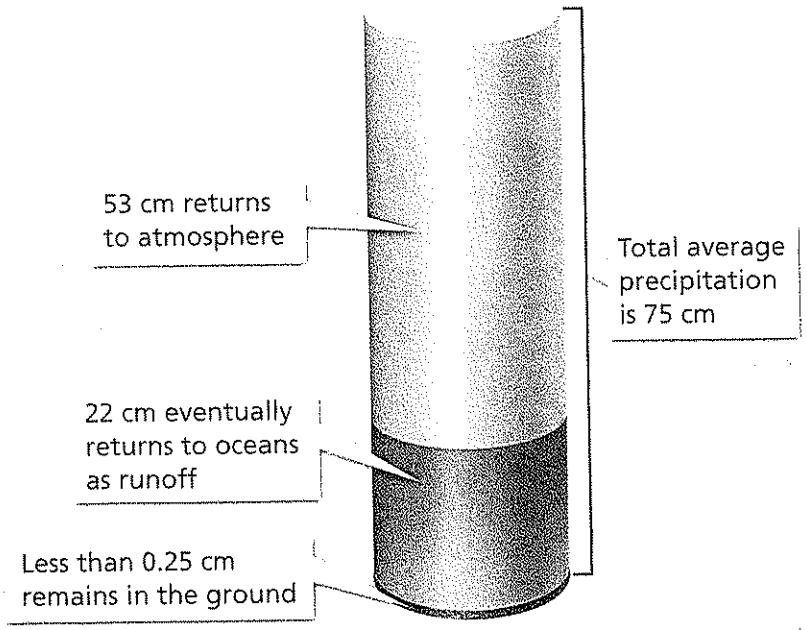


FIGURE 4
Where the Runoff Goes
Precipitation over the United States averages about 75 cm per year. About 22.5 cm becomes runoff. Most returns to the atmosphere by evaporation or through the leaves of plants.
Reading Graphs *How much runoff remains in the ground?*



Lab zone **Try This Activity**

Raindrops Falling

Find out how the force of falling raindrops affects soil.

1. Fill a petri dish with fine-textured soil to a depth of about 1 cm. Make sure the soil has a smooth flat surface, but do not pack it firmly in the dish.
2. Place the dish in the center of a newspaper.
3. Fill a dropper with water. Squeeze a large water drop from a height of 1 m onto the surface of the soil. Repeat 4 times.
4. Use a meter stick to measure the distance the soil splashed from the dish. Record your observations.
5. Repeat Steps 1 through 4, this time from a height of 2 m.

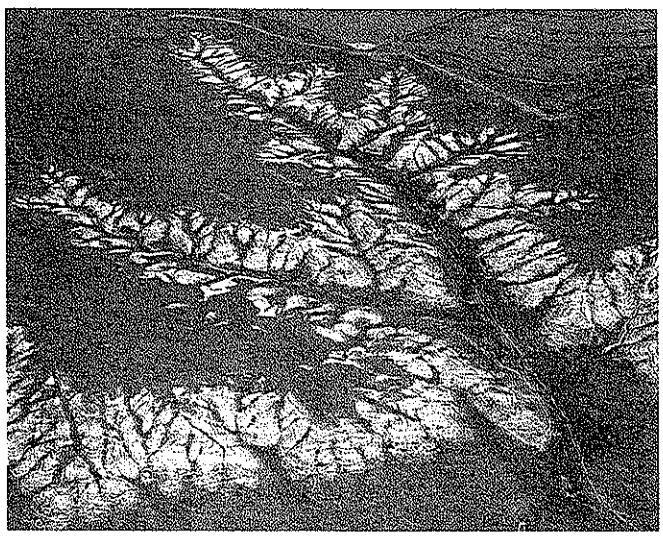
Drawing Conclusions Which test produced the greater amount of erosion? Why?

Rills and Gullies Because of gravity, runoff and the material it contains move downhill. As runoff travels, it forms tiny grooves in the soil called **rills.** As many rills flow into one another, they grow larger, forming gullies. A **gully** is a large groove, or channel, in the soil that carries runoff after a rainstorm. As water flows through gullies, it moves soil and rocks with it, thus enlarging the gullies through erosion. Gullies contain water only after it rains.

Streams and Rivers Gullies join together to form a larger channel called a stream. A **stream** is a channel along which water is continually flowing down a slope. Unlike gullies, streams rarely dry up. Small streams are also called creeks or brooks. As streams flow together, they form larger and larger bodies of flowing water. A large stream is often called a river.

Tributaries A stream grows into a larger stream or river by receiving water from tributaries. A **tributary** is a stream or river that flows into a larger river. For example, the Missouri and Ohio rivers are tributaries of the Mississippi River. A drainage basin, or watershed, is the area from which a river and its tributaries collect their water.

Reading Checkpoint **What is a tributary?**



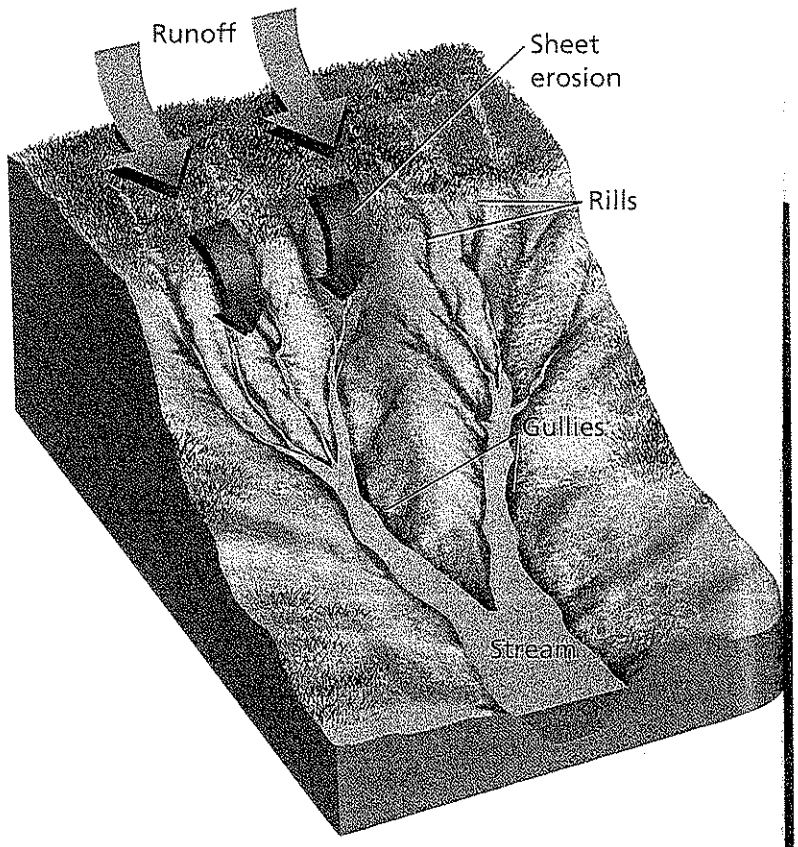


FIGURE 5
Runoff, Rills, and Gullies
Water flowing across the land runs together to form rills, gullies, and streams.
Predicting *What will happen to the land between the gullies as they grow wider?*

Erosion by Rivers

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As a river flows from the mountains to the sea, the river forms a variety of features. **Through erosion, a river creates valleys, waterfalls, flood plains, meanders, and oxbow lakes.**

Rivers often form on steep mountain slopes. Near its source, a river is often fast flowing and generally follows a straight, narrow course. The steep slopes along the river erode rapidly. The result is a deep, V-shaped valley.

Waterfalls Waterfalls may occur where a river meets an area of rock that is very hard and erodes slowly. The river flows over this rock and then flows over softer rock downstream. As you can see in Figure 6, the softer rock wears away faster than the harder rock. Eventually a waterfall develops where the softer rock was removed. Areas of rough water called rapids also occur where a river tumbles over hard rock.

Flood Plain Lower down on its course, a river usually flows over more gently sloping land. The river spreads out and erodes the land, forming a wide river valley. The flat, wide area of land along a river is a **flood plain.** A river often covers its flood plain when it overflows its banks during floods. On a wide flood plain, the valley walls may be kilometers away from the river itself.

FIGURE 6
How a Waterfall Forms
A waterfall forms where a flat layer of tough rock lies over a layer of softer rock that erodes easily. When the softer rock erodes, pieces of the harder rock above break off, creating the waterfall's sharp drop.

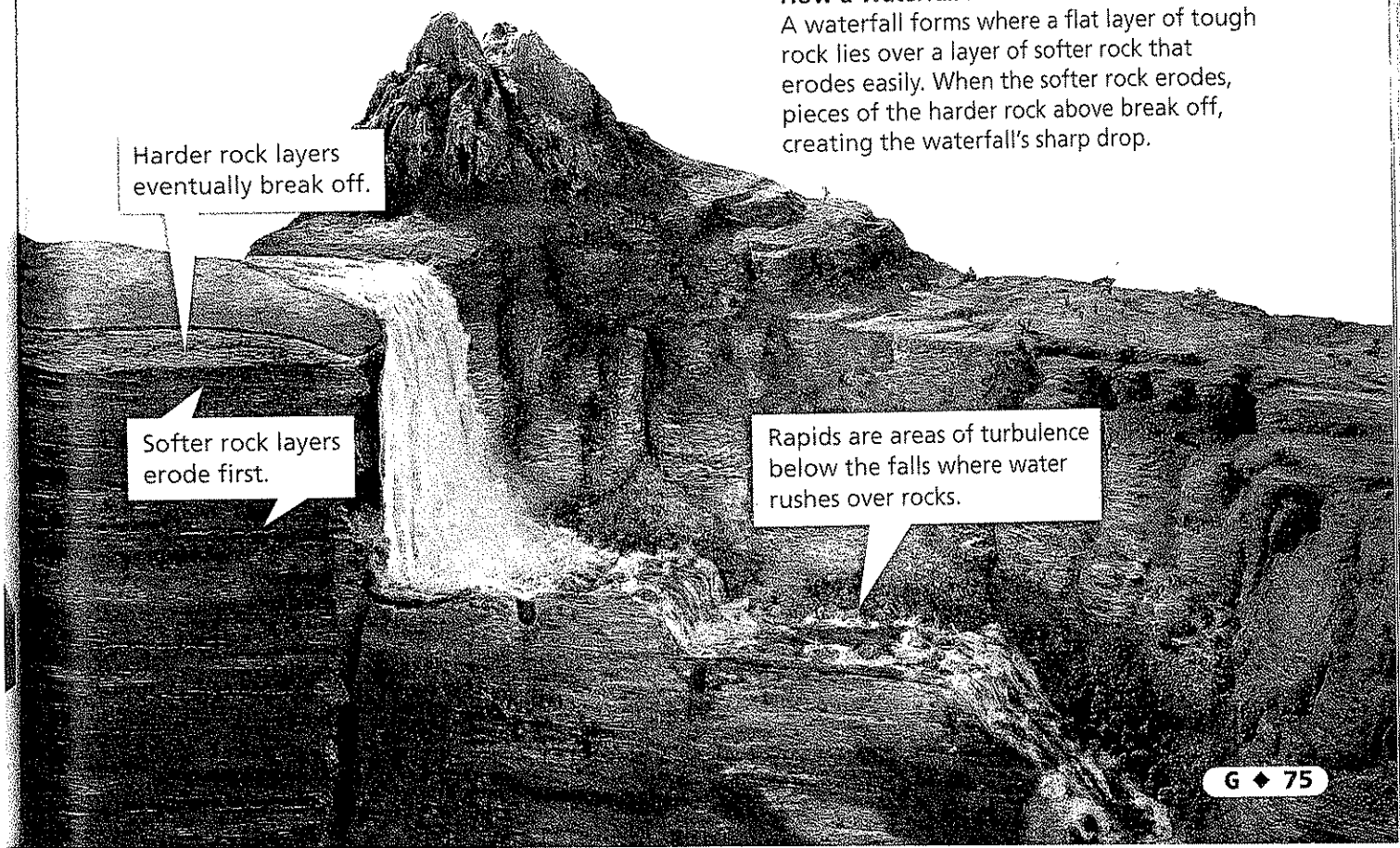
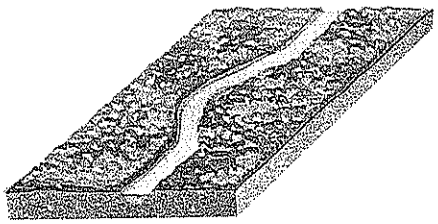
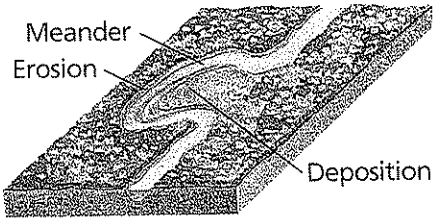


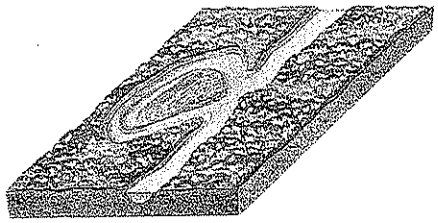
FIGURE 7
Meanders and Oxbow Lakes
Erosion often forms meanders and oxbow lakes where a river winds across its floodplain.



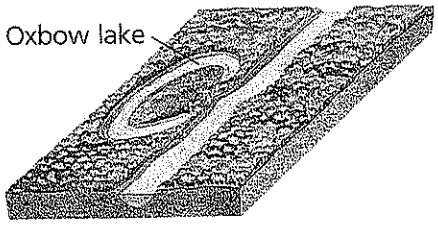
1 A small obstacle creates a slight bend in the river.



2 As water erodes the outer edge of a meander, the bend becomes bigger. Deposition occurs along the inner edge.



3 Gradually, the meander becomes more curved. The river breaks through and takes a new course.



4 An oxbow lake remains.

Meanders A river often develops meanders where it flows through easily eroded rock or sediment. A **meander** is a loop-like bend in the course of a river. As the river winds from side to side, it tends to erode the outer bank and deposit sediment on the inner bank of a bend. Over time, the meander becomes more and more curved.

Because of the sediment a river carries, it can erode a very wide flood plain. Along this part of a river's course, its channel is deep and wide. Meanders are common. The southern stretch of the Mississippi River is one example of a river that meanders on a wide, gently sloping flood plain.

Oxbow Lakes Sometimes a meandering river forms a feature called an oxbow lake. As Figure 7 shows, an **oxbow lake** is a meander that has been cut off from the river. An oxbow lake may form when a river floods. During the flood, high water finds a straighter route downstream. As the flood waters fall, sediments dam up the ends of a meander. The meander has become an oxbow lake.

Reading Checkpoint **How does an oxbow lake form?**

Deposits by Rivers

As water moves, it carries sediments with it. Any time moving water slows down, it drops, or deposits, some of the sediment. As the water slows down, fine particles fall to the river's bed. Larger stones quit rolling and sliding. **Deposition creates landforms such as alluvial fans and deltas. It can also add soil to a river's flood plain.** In Figure 10 on pages 78–79, you can see these and other features shaped by rivers and streams.

Alluvial Fans Where a stream flows out of a steep, narrow mountain valley, the stream suddenly becomes wider and shallower. The water slows down. Here sediments are deposited in an alluvial fan. An **alluvial fan** is a wide, sloping deposit of sediment formed where a stream leaves a mountain range. As its name suggests, this deposit is shaped like a fan. You can see an alluvial fan in Figure 8.

Deltas A river ends its journey when it flows into a still body of water, such as an ocean or a lake. Because the river water is no longer flowing downhill, the water slows down. At this point, the sediment in the water drops to the bottom. Sediment deposited where a river flows into an ocean or lake builds up a landform called a **delta.** Deltas can be a variety of shapes. Some are arc shaped, others are triangle shaped. The delta of the Mississippi River, shown in Figure 9, is an example of a type of delta called a "bird's foot" delta.

Soil on Flood Plains Deposition can also occur during floods. Then heavy rains or melting snow cause a river to rise above its banks and spread out over its flood plain. When the flood water finally retreats, it deposits sediment as new soil. Deposition of new soil over a flood plain is what makes a river valley fertile. Dense forests can grow in the rich soil of a flood plain. The soil is also perfect for growing crops.

Reading Checkpoint **How can a flood be beneficial?**

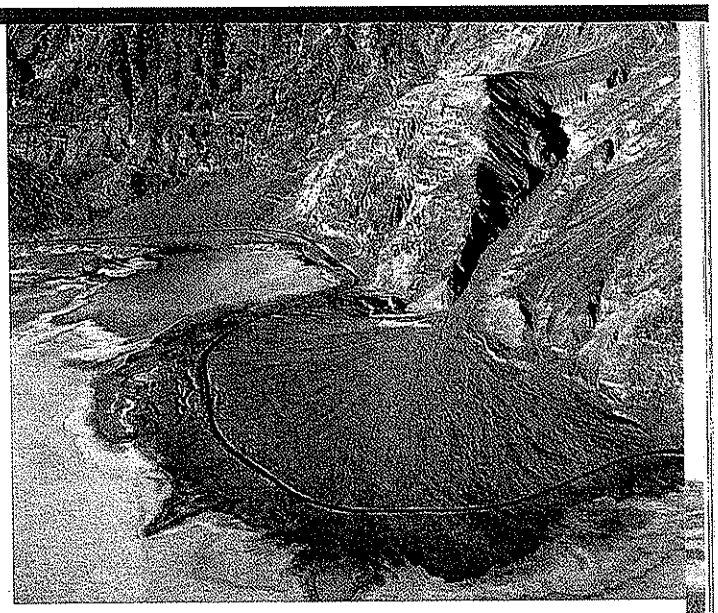
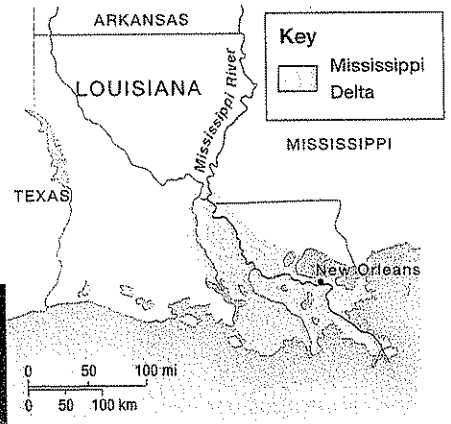


FIGURE 8
Alluvial Fan
This alluvial fan in Death Valley, California, was formed from deposits by streams from the mountains.



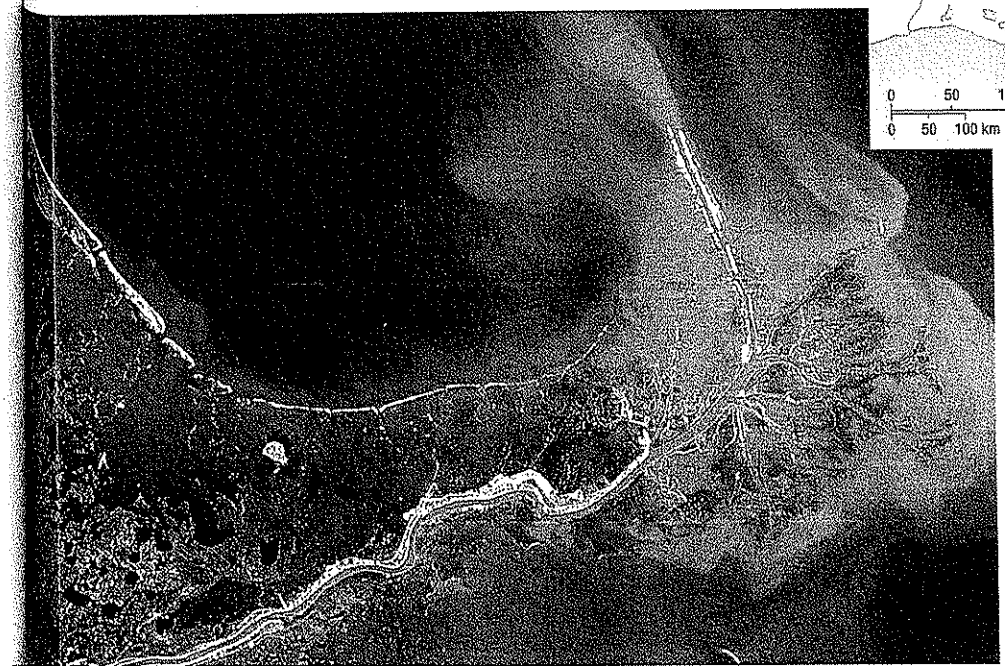
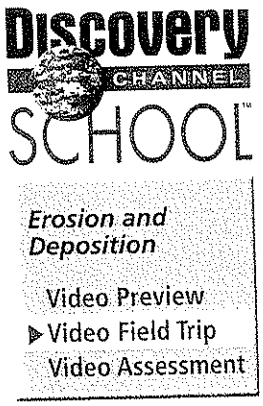


FIGURE 9
Mississippi Delta
This satellite image shows the part of the Mississippi River delta where the river empties into the Gulf of Mexico.
Observing *What happens to the Mississippi River as it flows through its delta? Can you find the river's main channel?*



Groundwater Erosion

When rain falls and snow melts, not all of the water evaporates or becomes runoff. Some water soaks into the ground. There it fills the openings in the soil and trickles into cracks and spaces in layers of rock. **Groundwater** is the term geologists use for this underground water. Like running water on the surface, groundwater affects the shape of the land.

Groundwater can cause erosion through a process of chemical weathering. When water sinks into the ground, it combines with carbon dioxide to form a weak acid, called carbonic acid. Carbonic acid can break down limestone. Groundwater containing carbonic acid flows into any cracks in the limestone. Then some of the limestone changes chemically and is carried away in a solution of water. This process gradually hollows out pockets in the rock. Over time, these pockets develop into large holes underground, called caves or caverns.

Cave Formations The action of carbonic acid on limestone can also result in deposition. Inside limestone caves, deposits called stalactites and stalagmites often form. Water containing carbonic acid and calcium from limestone drips from a cave's roof. Carbon dioxide is released from the solution, leaving behind a deposit of calcite. A deposit that hangs like an icicle from the roof of a cave is known as a **stalactite** (stuh LAK tyt). Slow dripping builds up a cone-shaped **stalagmite** (stuh LAG myt) from the cave floor.

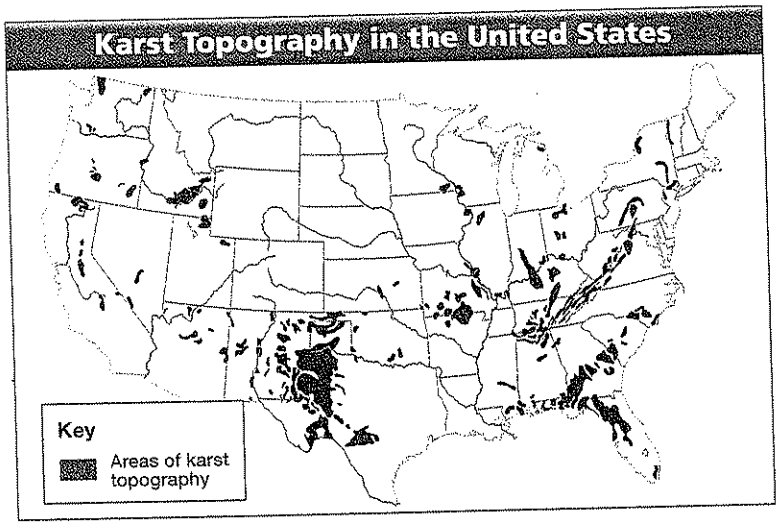


FIGURE 11
Karst topography is found in many parts of the United States where the bedrock is made up of thick layers of limestone.

Karst Topography In rainy regions where there is a layer of limestone near the surface, groundwater erosion can significantly change the shape of the land. Streams are rare, because water easily sinks down into the weathered limestone. Deep valleys and caverns are common. If the roof of a cave collapses because of the erosion of the underlying limestone, the result is a depression called a sinkhole. This type of landscape is called **karst topography** after a region in Eastern Europe. In the United States, regions of karst topography are found in Florida, Texas, and many other states.

Reading Checkpoint **How does deposition occur in a limestone cave?**